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China Report

SCIENCE AND TECHNOLOGY

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CHINA REPORT

SCIENCE AND TECHNOLOGY

CONTENTS

APPLIED SCIENCES

RESEARCH ON REMOTE SENSING TECHNOLOGY, APPLICATIONS REPORTED

Research Overview

Yinchuan NINGXIA RIBAO in Chinese 9 Sep 83 p 2

[Article: "Research on Remote Sensing Technology and its Application"]

[Text] Remote sensing technology, which came into being internationally in the sixties, uses such means of conveyance as airplanes or satellites to transport sensing instruments to high altitudes or space for receiving and recording the different electromagnetic wave radiation and reflection signals given off by various bodies and through imaging and data processing and analysis achieve the goal of surveying the earth's environment and prospecting for the earth's resources. Remote sensing technology brings together the newest achievements in space, electronics, optics and computer technology and is an important component of modern science and technology [S&T]. It is already ranked as one of the nation's key S&T topics.

The working distance of remote sensing has now increased to geosynchronous orbits at altitudes of over 30,000 km and working wave bands range from ultraviolet, visible and infrared light to microwaves, and working cycles have increased to dynamic remote sensing once every several tens of minutes. Remote sensing technology has formed a survey netowrk for observing and measuring the earth. Using this technology, macromaterials which cannot be secured on the earth's surface can be obtained and can guide such activities as agriculture, forestries, animal husbandry, fisheries, water conservancy, mining, environment and weather forecasting to use and transform nature better.

China is a vast country and has many regions where the population is sparse and communications difficult, thus for long a period of time the resource situation has been unclear. Carrying out surface surveys using conventional methods is not only time-consuming and expensive for some areas are very hard to get to, but even less is there any way of getting a good grasp of large-scale dynamic changes. Vigorously expanding applications and research on remote sensing technology has important significance for accelerating the finding out of China's natural resource situation, and promoting the development of industrial and agricultural production and S&T.

In line with the demands for key S&T missions during the Sixth 5-year Plan, in the next 2 or 3 years the first generation of domestically produced developmental models of such equipment as aerial sensors and computer imaging processing systems will be completed and put into operation. Research and application of aerial remote sensing for urban planning, selecting factory sites and choosing railway routes will be actively developed and energies concentrated on stressing satellite remote sensing materials in applications to national territorial resource surveys and area measuring, surveys of grasslands, forests, and coastal beaches, developing coal resources and large-scale agricultural engineering surveys to make remote sensing technology play an even greater role in national economic construction.

Other Projects Noted

Shanghai XIANDAI TONGXIN [COMMUNICATIONS TODAY] in Chinese, No 11, 1983 p 8-9

[Article by Cao Yongqiu [2580 3057 4428]: "Remote Sensing"]

[Excerpts] Applications of Remote Sensing in China

In recent years, remote sensing technology in China has developed very quickly and achieved certain results. At the end of October, 1981, the Second Asian and Pacific Region Conference on Remote Sensing was held in Beijing. A great many papers and specialized reports of high quality were presented.

Since the fourth satellite was launched on 26 November 1975, [satellites] have generally been successfully returned to the surface after completing their scientific experiment missions. Results from the aerial remote sensing materials provided by the image and data coordinating recording infrared imaging and multiple spectrographic scanning on the satellite in surveying the geology and geomorphology of some key regions and the distribution of forests in the Northeast, surveying sources of the Chang Jiang and Huang He, and the quantity and distribution of salt and freshwater lakes in the Qinghai-Tibetan Plateau were unprecedentedly good. When surveying such industrial cities as Shanghai and Tianjin, sometimes, even though the smoke from factory smokestacks was not black, the carbon monoxide and carbon dioxide content exceeded standards. In particular, after the Tangshan earthquake, detailed survey of the geology of the region had very important significance for construction of the new Tangshan, railway repair, and survey and determination of bridge sites.

Some valuable materials were secured when carrying out remote sensing of such cities as Beijing, Tianjin and Shanghai. For example, remote sensing imaging of geothermal water sources in the Beijing region showed that in the Baiyun rock stratum 500-1,000 m below the foothills of Yanshan there are many fissures and caverns which store abundant underground water and that active faults connecting with crustal depths can heat it up and raise the temperature of the water. On this basis, for several years Beijing has drilled 21 hot-water wells with water temperatures as high

as 69.5 degrees C. and as low as 38.4 degrees C. Or, as the satellite pictures told us, 460 million tons of mud and sand (which if piled up on the 30 sq km of Shanghai Municipality would be about 11 m high) enters the sea through the Chang Jiang delta annually. For this reason, the Chang Jiang estuary stretches 1 km further out to sea every 40 years. What is even more important, it clarified the trend and scope of sand and mud in suspension which the Chang Jiang carries into the sea, a crosswise range of 30-50 km and longitudinally from Lusi, Jiangsu, to the mouth of the Ou Jiang in Zhejiang and even to the estuary of the Min Jiang in Fujian, and provided important bases for studying the process of continental sedimentation, exploiting oil resources on the continental shelf, and developing navigation and fisheries production.

In applications in agriculture, Shanxi Province has obtained preliminary results. Using satellite photos, a "Taiyuan Portrait" of the Taiyuan region developed a series of pictures of the agricultural natural conditions in 20 odd-counties. This reflected in considerable detail the geology, geomorphology, water systems, forests, grasslands, land use, land types, land resources, planting situation and agricultural climatic divisions of this region and resolved in a preliminary way some problems which were heretofore difficult to resolve, such as pictures of ancient river channels, land use, geomorphological types and land types, materials which we did not have before.

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CSO: 4008/107

FUTURE DEVELOPMENT OF LOW-ALLOY STEELS VIEWED

Beijing GANGTIE [IRON AND STEEL] in Chinese No 8, 1983 pp 7-10

[Article by Liu Jiahe [0491 0857 4421] of the Central Iron and Steel Research Institute: "A Brief Review of Production and Application of Our Low-Alloy Steels and Some Ideas Suggested for Future Development"]

[Text] The meaning of low-alloy steels and the steel grades in our country are different from those of other countries. If the total amount of alloy elements is less than 5 percent and the alloy steels are to be supplied to consumers in the form of plates, pipes, wires or shaped steel, they can generally be made into finished products without being machined or heat-treated once again. In addition to the total range of steel grades included in the standards of low-alloy construction structural steels, there are still other grades included in another 18 special steel standards. They are generally called low-alloy steels in our country.

I. Achievements in Production and Application of Low-Alloy Steels in Our Country

Low-alloy steels were first trial manufactured in 1958 in our country. At that time, there was only one grade and an annual output of approximately 10,000 tons. After the national low-alloy steels meeting in 1960, the output sharply rose to 1.41 million tons and accounted for 9.7 percent of the total national steel output that year. The interference and disruptions in the 10 years of internal turmoil slowed down the development, and the quality of products went up and down. After 1977, low-alloy steel production recovered and developed, and the annual output rose to 1.94 million tons in 1977 and 3.02 million tons in 1980. The output dropped in 1981 because of the industrial readjustment, but this was followed by an upswing in 1982.

Low-alloy steels in our country are mainly of three categories: all-purpose low-alloy welded structural steels, 27 percent; low-alloy steel bars for construction, 42 percent; low-alloy wear-resistant steel rails, 18 percent; and others, 11 percent. As to the method of smelting, 60 percent of them are from open hearths and 40 percent are from converters.

Our country has successfully trial manufactured more than 100 grades of steel and 60 of them have been recommended to various sectors of the national economy.

Below is a brief introduction to several categories of steels with fairly large outputs.

1. Low-alloy high-strength steels for welded structures.

At present, those with strengths of 30-45 kgf/mm^2 have been initially serialized, and 18 grades have been included in state standards. The most popular one is 16 Mn steel which accounts for 27 percent of the total low-alloy steel output. This steel is used, for example, in the Nanjing Bridge and the Guangzhou TV Tower, and also for making spherical gas (storage) tanks for both home use and for the petrochemical industry. It is now mainly produced by open hearths and delivered in a hot-rolled state, a small amount of it is normalized. Steels of even higher strength after thermal refining are also in serial production for special uses.

2. Low-alloy high-strength steel bars for construction.

At present, approximately one-sixth of all steel bars used in our country are made of low-alloy steels. Such steels are used in all hot-rolled steel bars and prestressed steel bars above grade 1. According to the calculations of construction departments, the use of low-alloy steels in certain structures, compared with the use of carbon steels, can result in a saving of 20-40 percent in steel. The railway departments used heat-treated steel bars to reinforce concrete ties, and each ton of heat-treated steel bars used means a saving of 12-16 m^3 of timber. China is more than self-sufficient in low-alloy steel bars and exported more than 100,000 tons of them last year. This category of steel is mainly produced by converters and delivered in a hot-rolled or controlled-cooling state.

3. Low-alloy wear-resistant steel rails.

There are now five grades of steel standardized by the state and approved by the ministry. The use of medium manganese steel, trial manufactured in our country, can double the service life of the rails in large-curve tracks. Again, if high silicon steel rails are used in small-curve tracks, their service life can be three times that of carbon steel rails. The Wuhan Iron and Steel Co has supplied more than 100,000 tons of manganese steel rails for building the Tanzania-Zambia Railway.

Other varieties of low-alloy steels to be used for coal mining, for making boilers and petrochemical containers, and for shipbuilding have also shown good results.

While developing new materials, we have also made many achievements in technology. Examples are: the technique of deoxidation with deoxidation compounds and for microalloy; the technique of powder-blowing for desulfurizing; and the technique of removing impurities by spraying. In steel rolling, we have also developed the technique of controlled rolling and of cooling through water in the utilization of residue heat after rolling. Some factories have designed and manufactured continuous normalizing furnaces and tempering furnaces, pressure quenching machines and other heat-treatment equipment. In addition, we have developed the technique of nondestructive flaw testing.

Along with the development of low-alloy steels, the scientific research units have not only introduced many new grades, but have also solved such technical problems as the prevention of accretion at the water level in rare earth steels, the additive method to raise the rare earth recovery rate, the special measures for reducing surface oxidation for chromium-nickel steels, the heat-cracking of copper containing steels, and the welding of high-strength steels. Many new improvements have also been made in applied theories.

II. Shortcomings and Problems

Despite the great improvement in production and development, low-alloy steels still leave much to be desired in meeting the requirements of the national economy and are far below the advanced levels, as shown in the following prospects.

1. In output ratio: Though accounting for 9 percent of the total steel output, our low-alloy steel output still fails to match with our abundant natural resources and is inadequate for the upgrading of our products. It is difficult for us to compare our products with foreign products in view of the different criteria of classification and statistics. If we look at the Soviet Union, for example, (see Table 1) we will see that the ratio of low-alloy steels to the total steel output in our country is quite low. To meet our requirements, it should be above 15 percent in 1985.

Table 1. Ratios of Low-Alloy Steel Output in the Soviet Union in 1960-1985

1960	1965	1970	1975	1980	1985 (estimated)
		(in percent)			
5.8	7.6	10.1	12.8	15 (approx)	20

2. In varieties: Although 60 grades have been recommended for use, only a few of them are being mass produced. Atmospheric-corrosion-resistant steel can be produced by using the residue elements of pig iron; however, the use of this steel has only begun on railway rolling stock, but not yet popularized in bridge building. In the United States, atmospheric-corrosion-resistant steel was used in 15 percent of the steel bridges in 1970; in 1978, it was used in 43 percent of them. In Japan, it was used in approximately 23.5-35 percent of the bridges. See Figure 2.

Our country has abundant resources for microalloy steel which is compatible with the orientation of our modernization. However, it has not been developed on a large scale. The steel used for making steel bars in our country, for example, is mainly hardened with silicon-manganese solid solution, while the output of microalloy steel with precipitation hardening is very low. Some West European countries, however, have undergone great changes in the past decade. From the ratios of sales by Halmstads Plant, Sweden, in 1970 and 1980, we can see the trend of their developments. See Figure 3.

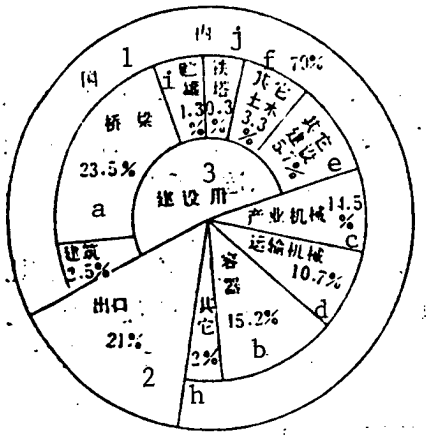

Figure 2. Atmospheric Corrosion Resistant Steels Used in Different Ways in Japan (Average annual output 1974-1978)

Key:

1. Domestic use, 79 percent
2. For exports, 21 percent
3. For construction
a. Bridges, 23.5 percent
b. Containers, 15.2 percent
c. Industrial machinery, 14.5 percent
d. Transportation machinery, 10.7 percent
e. Other construction projects, 5.7 percent
f. Other civil engineering projects, 3.3 percent
g. Buildings, 2.5 percent
h. Others, 2 percent
i. Cylinders, 1.3 percent
j. Towers, 0.3 percent

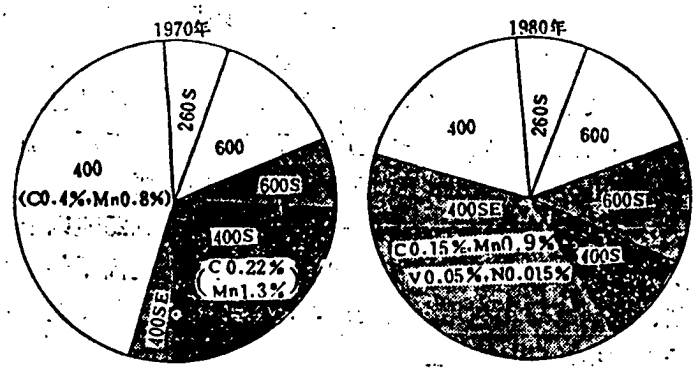

Figure 3. Change in Composition of Sales by Halmstad Plant of Sweden From 1970 to 1980

Trial production of other products, such as high-strength steel for mechanical engineering with a yield strength of more than 70 kgf/mm^2, Z-shaped steel strips, and crackfree welding steel, is just beginning and their output is not enough for the newly emerging industries and new machinery. Furthermore, the specifications of plates, pipes, shapes, straps, and welding materials are not complete to form whole sets.

3. In quality: The properties of many products are not well balanced or stable, and some of them are not up to the advanced standards. The impact toughness, in particular, is far behind that of foreign brand-name products. There are also many problems with the tolerances, location dimensions and surface qualities.

4. In production technology: In the course of technical transformation, many modern technologies, such as secondary refining, continuous ingot casting, controlled rolling, controlled cooling and continuous annealing are not yet in popular use.

5. In scientific research: The solution of some technical problems of strength versus weldability and strength versus toughness are still in progress, while work on scientific and technical problems of strength and shaping is just beginning. Furthermore, the investigation and study in market conditions, the varieties of iron alloy, the development of welding materials and welding techniques, and the rational selection of materials are still far from adequate.

III. Ideas for Future Development

In his report on the Sixth 5-Year Plan, Premier Zhao Ziyang pointed out: "We should make full use of China's fairly abundant mineral resources to produce alloy steel, low-alloy steel in particular, and increase their proportion of total steel output as a major policy for the technological development of our metallurgical industry. We must bear in mind the grand strategy of quadrupling the gross value of our agricultural and industrial output by the turn of the century. However, because of the restrictions from energy, it will be difficult for the steel output to keep pace with other developments. To make up the shortage in quantity with better quality; to bring into play our country's strong point in the resources of nonferrous mineral in line with the inevitable trend in the development of steel products; and to meet the needs of technical transformation and the updating of products, the vigorous development of low-alloy steels is not only a temporary expedient, but also a long-term strategic policy. The following measures are suggested for the implementation of this important technical policy:

1. We should strengthen the investigation and analysis of market conditions at home and abroad. In coordination with the progress of technical transformation and the upgrading of products, and to meet the requirements of key capital construction projects, and particularly the potential of the huge market for light industry and agriculture, we should work out fairly reliable plans of development and avoid the production of unwanted goods, the lack of coordination, and the improper use of materials with poor economic results.

2. To boost the output of low-alloy steels, we should increase the proportion of low-alloy steels produced by oxygen-converters. At present, their output is less than one-half of the total steel output, and they are mainly in the form of steel bars. We should encourage the plants using converters to refine more low-alloyed steels, and to produce more minor items as accessories for the steel plates produced by large plants. Since approximately one-third of

all low-alloy steels are now refined with the open hearths of Anshan Iron and Steel Co, other large open hearths should also produce low-alloy steels. In addition to steel plates, they can also produce skelps or heavy rails.

3. New technologies should be adopted to speed up technical transformation so that our products can approach or catch up with the advanced international standards or the advanced levels.

Considering the fact that a fairly long period has to elapse for technical transformation in our metallurgical industry, we must realize that advanced equipment and technology will have to coexist with minor renovations and intermediate technology. Therefore, products of high, medium and low grades are all required on the market. While stabilizing, improving and popularizing the low- and medium-grade products, we should at the same time accelerate the technical transformation in some key plants which produce high-grade products, in order to meet the requirements of newly emerging industries (such as atomic power generation and offshore oil drilling) and new machinery and equipment.

As for the orientation of technical transformation, the converters and electric furnaces should be altered so as to increase their capacities to more than 25 tons to facilitate continuous casting. We should also raise the ratio of low-alloy steels from continuous casting in order to increase the percentage of useful materials; and add more powder-spraying equipment to open hearths to improve the quality of open-hearth steels. In plants where conditions permit, the technique of controlled rolling, controlled cooling and the utilization of residue heat should be popularized to improve the quality and to reduce energy consumption. The increase in test equipment including the equipment for nondestructive flaw testing should deserve high priority and such equipment should be installed soon.

4. The technical line for producing low-alloy steels should be adopted after full appraisal and comparative tests.

Because of different conditions of resources and different customs and habits in different countries, their technical lines cannot be the same. For the production of wear-resistant heavy rails, for example, the Soviet Union and the United States are using carbon steels which are thoroughly quenched to increase their wear-resistant and fatigue-tolerating properties. The West European countries, however, are taking the line of alloy steels. The former countries can save on alloy elements and are accustomed to their production and application methods. The latter countries have to consume more alloy elements; however, they can simplify work sequences in a later stage, improve weldability and reduce energy consumption. The former method is adapted to plants already having total quenching equipment, while the latter method is advantageous to our country in developing our superiority in resources. Again, in the case of low-alloy steel bars, the Soviet Union, having fairly abundant manganese resources, adopts the technical line of increasing strength with manganese-silicon solid solution whereby the production can be easily managed. However, because of the effects of the hardenability band, it is difficult to have homogeneous properties, and the weldability is poor.

Some countries adopt the line of microalloy with V, Ti and Nb which provides good weldability and homogeneous properties for the products. However, this technique has to be strictly controlled. Again, in controlling the state of impurities; some countries use the method of rare-earth treatment; others use the method of spraying silicon-calcium for historical reasons or through force of habit in production. Therefore, we must conduct overall technical and economic comparisons and decide on our choice in accordance with concrete conditions.

5. We must intensify the development of materials for iron alloy and of welding. These are the two conspicuous weak links in the development of low-alloy steels in our country. To increase the number of steel grades and to lower the product cost, we must fully recognize the need for their popularization.

6. We must carefully select the tasks and accordingly organize the forces from various quarters for their accomplishment. Based on our needs in the near future, the following are suggested for priority development:

Atmospheric-corrosion-resistant steels for railway rolling stocks; low-alloy wear-resistant steel rails; steels for oil drilling platforms; steel for petroleum and natural gas pipelines; steel for intensive coal mining; high-strength steel bars; high-strength steel for mechanical engineering; iron alloy powders and new iron alloy; auxiliary welding materials and welding agents.

To remedy such defects as excessive manpower in producing new materials and the lack of attention to techniques and technologies, we should organize more forces in making a breakthrough in new key technologies. Applied theories are the foundation of technical renovation and must be highly regarded in solving every key problem.

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Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese No 9, 1983

[Text]

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CSO: 4008/192

DEVELOPING SECOND GENERATION OF MILITARY VEHICLES

Changchun QICHE JISHU [AUTOMOBILE TECHNOLOGY] in Chinese No 10, 1983 pp 22-23

[Article by Feng Chao [7458 6389]: "Highlights of the Second Generation of Military Motor Vehicles"]

[Excerpt] II. Some Thoughts on Developing a Second Generation of Military Vehicles for China

Right after Liberation, China did not produce its own military motor vehicles, but used several kinds of Soviet-style vehicles and some outdated America vehicles. But the variety was incomplete, not forming a system, and they did not meet the need. In the 1960s, with the development of the automobile industry and with the united efforts of both the military and civilians, we gradually developed and produced 10 vehicle models (BJ212, NJ221, NJ230, CA30, EQ240, EQ245, SX250, LT665, JN252, and CQ261) --from the jeep to the heavy-duty cross-country vehicle--in accordance with the needs of the armed forces, thus achieving great success in creating China's first generation of military motor vehicles.

At present, the work of developing China's second generation of military motor vehicles in accordance with the demands defense modernization has already been placed on the agenda. Consequently we have studied and summarized the experiences and lessons in developing our first generation of military motor vehicles, referred to the experiences of foreign countries in their development of a second generation of military vehicles, and examined the relationship between our direction in developing the next generation of military motor vehicles and military and civilian products. This is an extremely significant task and requires the joint conscientious study of both military and automobile industry departments.

At the same time that we affirm our accomplishments, everyone should note that our first generation of military motor vehicles had the following major problems:

1. The most obvious contradiction facing us is the lack of dependability. This is a very widespread problem. Although the dependability of the various models varies, still, for all of them, the mileage that they can

go without a breakdown is fairly low. The foreign goal for miles without breakdown is between 10,000 and 16,000 km. But it will take a tremendous amount of effort for us to raise our average mileage without breakdown to about 2,000 km.

2. Coordination between the military and the civilian is not good, and we fall short in interchangeability and seriation. Many military vehicles are of a special construction for a particular use and are often incompatible with civilian vehicles, or the degree of interchangeability is slight. Examples of the former are the Hongyan CQ261 and Dongfanghong 665. Examples of the latter are the Yan'an SX250 and Huanghe JN252, etc. The Huanghe models 150 and 252 which are both produced in the Ji'nan Automobile Plant, have over 80 percent basic incompatibility in parts in the frame, driver's cab, transmission, suspension systems and steering systems. In addition, there is incompatibility between various models of military vehicles, to the point that there are very few interchangeable standard items in the instrument panel and accessories.

3. There is an incomplete roster of types, there are too few varieties, and model changes are difficult. Vehicles are all basically one of a kind, but still there is even duplication within the same tonnage class. For example, the Huanghe 252, Yan'an 250 and the Dongfanghong 665 are all in the 5-ton class of cross-country vehicles. Yet up to the present, we still do not have a heavy-duty cross-country vehicle of over 7 tons.

4. Performance norms are backward; compared to present average international levels, and the principle standards for such things such as specific power, performance, economy, ability to go cross-country, smoothness, etc. for major vehicle models are all rather backward, and cannot meet the requirements of national defense modernization.

5. Basically they are all middle-grade maneuverability vehicles and we have no truly top-grade maneuverability vehicles. And we also lack necessary economical vehicle models. Under many circumstances, we can only use four-wheel drive cross-country vehicles of middle-grade maneuverability to meet various uses.

Looking at the above circumstances, it seems that we should get a good handle on the following links as we begin to develop our second generation of military motor vehicle:

1. Requirements clearly set forth by the military to suit our national defense policies and planned weaponry and which concern the various aspects of the types of military motor vehicles, their uses, and the models and varieties needed should be the basic foundation of developing the second generation of military motor vehicles.

2. The military and civilians should jointly study, go through discussions and proof, to formulate the concrete development plans for the second generation of military motor vehicles in accordance with tactical and technical requirements and what is actually possible in production and technology.

3. The basic principles for determining military-civilian applications should be to, after meeting the prerequisite of satisfying the basic functional requirements of military motor vehicles, research and develop new military vehicles based on tried and proven civilian vehicle assemblies.

4. Strive to do well in the three transformations work between military and civilian products and in the three transformations work between the various military vehicles.

5. The first thing we should stress in developing the second generation of military vehicles is raising dependability. At the same time, we should also pay attention to other aspects, such as improving suitability to climates (high and low temperature working conditions), ability to go crosscountry (emphasis should be on tires), convenient maintenance and the special requirements of military motor vehicles.

6. The new second generation military motor vehicles should primarily be high performance middle-grade maneuverability vehicle. At the same time, to the extent that circumstances permit--taking into account the state of the country--we should set about considering the question of developing a high maneuverability military vehicle, inquire into the practical problems of a central tire inflation device and hydraulic (or electronic) automatic transmissions.

The most obvious problem is that of clarifying military-civilian collaboration and clarifying a design using the civilian auto assembly as the basis [of the military vehicle]. This was also a common feature of foreign second generation military vehicles. In the process of developing our first generation of military motor vehicles, just as in foreign countries, we stressed the military to a greater or lesser extent, using the principle of having the military lead the civilians. The actual experience of those years--particularly the experience of certain major automobile plants--shows that this principle presented many problems to both the military and to the automobile industry. At present, China's automobile industry is just at the point of reorganizing its system, renovating their products and reorganizing their overall planning. Civilian automobiles also have a widespread problems in making model changes. Consequently, doing a good job in handling the problem of joint military-civilian development of our second generation of military vehicle will doubtlessly have an important bearing on both the armed forces and the automobile industry.

Now, under the guidance of the 12th CPC Congress line, a new situation in social construction is taking shape, and in accordance with the Party Central Committee's policy decision which stresses solving problems of energy resources and transportation, the automobile industry is certain to develop quite well. And we are convinced that at the same time it will make the proper contribution to the development of China's second generation of military motor vehicles.

12452
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THERMOHYDRAULIC CHARACTERISTICS OF VERTICAL-TYPE NATURAL-CIRCULATION STEAM GENERATOR

Shanghai DONGLI GONGCHENG [POWER ENGINEERING] in Chinese No 4, 15 Aug 83 pp 24-30

[Article by Ding Xunshen [0002 6064 1947] of the 719 Institute under the No 7 Academy: "The Thermohydraulic Characteristics of a Vertical-type Natural-circulation Steam Generator"]

[Text] ABSTRACT: Corrosion damage to heat exchanger tubes of the steam generator in a pressurized water reactor is a frequently encountered incident in a nuclear power plant. It greatly affects the reliability and economics of the nuclear power plant. In this paper, measures to improve the structural design were presented based on the thermohydraulic characteristics of the steam generator. The heat transfer and two-phase flow in a steam generator were introduced. The emphasis was placed on the the analysis of the thermohydraulic characteristics in certain areas.

I. INTRODUCTION

Heat generated by a pressurized water reactor is transferred from the water in the primary loop to the medium in the secondary loop through the heat transfer tube bundle in the steam generator to generate a certain amount of steam for the turbine. Thus, on the secondary-loop side of the steam generator a two-phase flow involving the heat transfer of a steam-water mixture is created. The heat transfer and flow take place simultaneously and are closely related. This is a problem of thermohydraulic characteristics. The intensity of fluidized heat transfer is usually very high, causing the two-phase flow pattern and thermohydraulic characteristics to vary. Changes in thermohydraulic characteristics will also affect heat transfer. Thus, a number of noticeable heat transfer and flow problems are raised. Moreover, the cost effectiveness of the steam generator and particularly its reliability are greatly affected. The study of thermohydraulic characteristics mainly involves the study of the temperature field on the surface of the tube, the gravimetric steam content, the initial position of boiling and the water

flow condition. It also includes the investigation of the effect of the alternate wetting and drying of the outer wall of heat exchanger tube, the variation of tube wall temperature and the flow-regulating damper. Furthermore, experimental thermodynamic and hydraulic results are compared to the calculated data. More importantly, it is often heat transfer tube bundle to prevent corrosion. Both experimental and mathematical modeling methods are used abroad to study the thermohydraulic cahracteristics of a steam generator.

Model tests on the thermohydraulic characteristics were published in References [2-4], with the objective of studying the ocrrelation between thermohydraulic characteristics and corrosion of the heat exchange tube. Reference [5-8] reporeted the use of a multidimensional mathematical model to study thermohydraulic characteristics.

The pilot testing of the thermodynamics and water circulation of a vertical natural-circulation steam generator had been carried out on high-temperature, high-pressure test stands in China.[9, 10] The tube wall temperature along the height of the tube bundle, the temperature of the secondary-loop working medium, the resistance in the riser tube bundle of the secondary loop, the resistance in the steam-water separator and the circulation ratio were measured.

In this paper, the heat transfer and two-phase flow in a vertical-type natural-circulation steam generator were introduced. The emphasis was on the analysis of the thermohydraulic characteristics in certain areas. Furthermore, measures to improve these characteristics were also proposed.

II. Heat Transfer and Two-phase Flow in Steam Generator

A vertical-type natural-circulation steam generator is shown in Figure 1. Feedwater enters the jacketed cylinder top through the annular waterpipe, mixing with recirculated water from the steam-water separator on the shell side and then flowing down through the annular gap between the shell and the jacket. Super-cooled water enters the tube bundle radially on the shell side from the bottom and flows upward. There is apparently a pre-heating zone in the lower portion of the tube bundle because of the lack of a certain amount of heat in the secondary-loop working medium at the inlet of the riser. At the exist of the pre-heating zone, the secondary-loop working medium reaches its saturation temperature and boils over to produce steam. The gravimetric steam content continues to increase all the way to the exit of the tubes. This is the evaporation section. The circulation ratio of this type of steam generator is usually 3-5, which means that the gravimetric steam content of the steam-water mixture leaving the heat transfer surface is 20-33 percent. The heat load of the primary-loop water flow along the U-shaped tube varies. It is higher on the hot side of the tube bundle than on the cold side. Across the same cross-section of the tube bundle, the gravimetric steam content on the hot side is greater than the cold side.

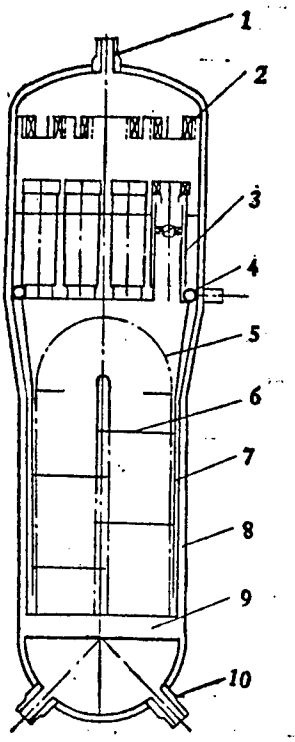

Figure 1. Verticle-type Natural Circulation Steam Generator

KEY:
(1) Steam outlet
(2) Fine separator
(3) Coarse separator
(4) Annular feedwater tube
(5) Tube bundle
(6) Support plate
(7) Jacketed cylinder
(8) Case
(9) tubesheet
(10) Inlet and outlet of primary-loop water

1. Boiling Heat Transfer

In the evaporating segment, it belongs to principal boiling, i.e., nucleate boiling in a saturated fluid. When the average heat load is normally about $0.5 \times 10^5 - 2 \times 10^5$ kcal/cm^2, the circulation ratio is not very high and the circulating speed is not very fast. Boundary layer disturbance caused by the generation, growth and separation of bubbles which are related to factors such as heat load and pressure has a primary effect on heat transfer. The effect of circulating speed, gravimetric steam content and the gap between tubes is not significant. Most of the references recommended the large space heat transfer formula for the evaporating segment. However, even within a similar range of working parameters, the difference is still large when different formulas are used. The Rohsenow large-space boiling heat transfer

formula [11] has been adopted in the United States and West Germany. In the USSR, the large-space boiling heat transfer formula [12] developed by the Central Boiler Turbine Institute [TsKTI: Central Scientific Research, Planning and Design Boiler and Turbine Institute imeni I. I. Polzunov] is used. In Reference 9, the Kutateladze large-space boiling heat transfer formula was recommended. Furthermore, it was pointed out that this formula was closer to the experimental data than the Rohsenow formula and the Central Boiler Turbine Institute formula.

Heat is transferred from the tube wall to the secondary-loop working medium in the pre-heating zone. When the load is low, it may belong to a convection heat transfer. When the load is high, it may belong to a surface boiling heat transfer, or surface boiling heat transfer on the hot side and convection heat transfer on the cold side.

The curves shown in Figure 2 are the variations of primary-loop water temperature, secondary-loop working-medium temperature and tube wall temperature along the primary-loop water flow path obtained experimentally[9]. The figure indicates that Section I belongs to exuberant surface boiling heat transfer, Section II to principal boiling heat transfer, Section III to non-exuberant surface boiling heat transfer and Section III to convection heat transfer.

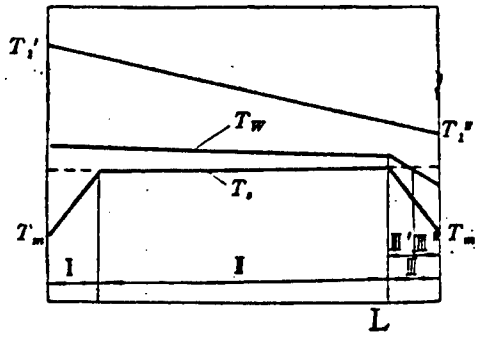

Figure 2. Variations of Primary-loop Water Temperature, Secondary-loop Medium Temperature and Tube Wall Temperature along Primary loop Water Flow Path.

T_1', T_1'' - Primary-loop water temperatures at the inlet and outlet of the steam generator; T_w - outer-wall temperature of the heat transfer tube; T_s - secondary-loop working-medium temperature; T_m - secondary-loop working-medium temperature at the inlet of the ascending path; and L - average length of the U-shaped tube bundle.

It was pointed out in Reference [9] that the presence of a pre-heating zone could be neglected and the entire heat transfer surface could be treated as the evaporating segment in calculating the heat transfer. The calculation could thus be simplified, and the results were also more reliable.

2. Two-phase Flow

In a steam generator, the heat transfer and two-phase flow pattern are closely correlated. Different flow patterns affect the fluid dynamics near the heat transfer surface differently, creating various frictional pressure drops and heat transfer modes.

In the mainstream boiling region, two-flow patterns will usually emerge, i.e., bubble flow and annular flow. In a bubble flow, the bubbles are homogeneously distributed in the saturated fluid. A super-heated liquid layer is present near the heat transfer surface which continuously delivers non-shrinking bubbles to the fluid. Such a flow pattern occurs when the cross-sectional stream content is low. When the cross-sectional steam content continues to increase, the flow speed of steam will exceed that of water in an accelerating two-phase flow. At the same pressure gradient, steam will obtain higher kinetic energy and speed than water. Therefore, bubbles are concentrated in the high-speed region in the center to create an annular flow. In an annular flow, most of the liquid continues to stay near the wall. The remaining liquid is distributed in the continuous steam flow pattern of a two-phase flow during heat transfer; therefore, it is difficult to determine accurately the boundary point between the bubble flow and the annular flow along the height of the tube bundle in a steam generator.

Two-flow models can be used to analyze and calculate the cross-sectional steam content and pressure drop of a two-phase flow: homogeneous-phase model and sliding model. In the homogeneous-phase model, a two-phase flow is considered to be a single-phase flow with average physical properties derived from the physical characteristics of both phases. Furthermore, it is assumed that the linear velocity of steam is equal to that of water with a ratio equal to one, and the two phases are in a thermodynamic equilibrium. For a bubble flow, as long as the cross-sectional steam content is determined accurately, the homogeneous-phase model is more reliable than other methods. The sliding model is represented by Martinelli and Nelson. It is considered that the gas phase and liquid phase are completely separate and independent flows. The frictional-pressure drop per unit of tube length is the same for gas as for liquid, and the mutual interaction between the two phases is not taken into account. In Reference [10], it was recommended that the Martinelli method be used to calculate the pressure drop in the riser of the steam generator, i.e., the frictional-pressure drop of the two-phase flow is expressed by multiplying a coefficient to the frictional-pressure drop of a single-liquid phase or a single gas phase flow alone.

In the riser of a steam generator, a flow distribution damper, support plate, vibration-proof rack and J-shaped bend are arranged. In order to calculate the values of the localized two-phase resistance, these localized resistance coefficients must be determined experimentally.

III. Thermohydraulic Characteristics in Certain Regions

An inverted U-shaped tubesheet structure is used in a vertical-type natural-circulation steam generator. Support plates are arranged at a certain spacing

along the tube bundle. A vibration-proof rack is placed at the U-shaped bend. Thus, a stagnation zone and a crevice zone are created in the riser with two-phase heat transfer. Corrosion damage to the heat transfer surface usually occurs in these regions. Hence, it is necessary to analyze and study the thermohydraulic characteristics in these regions.

1. Mud Sediment on Upper Tubesheet Surface

After operating for a period of time, steam generator designs earlier accumulated a considerably thick mud sediment on the tube-sheet. It was pointed out in operating experience [14] that sedimentation occurred in the stagnation zone* when the flow speed of the secondary-loop working medium at the tube bundle inlet was less than 0.38 m/sec because a drain pipe was not installed. In an operating steam generator manufactured by Westinghouse in the U.S., the mud sediment thickness could reach as high as 200-300 mm. The measured sediment thickness reached 400 mm in steam generators produced by the Power Station League in West Germany. Earlier, stress corrosion cracking and wall thinning of heat transfer tubes took place on the hot side in the sedimentation zone.

When the sediment reached a certain height, the mud sediment layer is divided into a wet, an alternately wet and dry and a steam cushion zone, as shown in Figure 4. In the wet zone, the fluid on top flows downward, and the steam-water mixture near the tube wall flows upward. Impurities will not be concentrated. On the bottom of the sediment, liquid cannot penetrate that far to replace the fluid evaporated, thus creating a steam cushion. This is the steam cushion zone, where the steam temperature is close to the primary-loop water temperature in the pipe. Usually, impurities will not be accumulated there. In the wet and dry region in between, impurities will be concentrated, and the heat transfer surface wetted and dried alternately. In this case, the thermal conductivity of the working medium in a porous sediment layer is related to the water content. Varying water content leads to changing thermal conductivity, which causes the local heat load on the heat transfer surface to vary so that the tubes are placed under a thermal stress cycle.

2. Crevice between Tube and Tubesheet

In the steam generators designed earlier, a gap of the order of several tenths of a millimeter was created between the tube and the hold in the upper part of the tubesheet in manufacturing. Because the inlet temperature of the water in the primary loop is usually greater than the saturation temperature of the secondary-loop medium by approximately 40°C, the tube wall in the crevice is in a strongly corrosive condition in operation. The mud sedimentation is shown in Figure 5. The upper part of the crevice is the

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*Stagnation zone--Two low-flow-rate areas are created on the hot and cold sides of the upper tubesheet surface because of the 90-degree turn of the circulating water coming into the tube bundle.

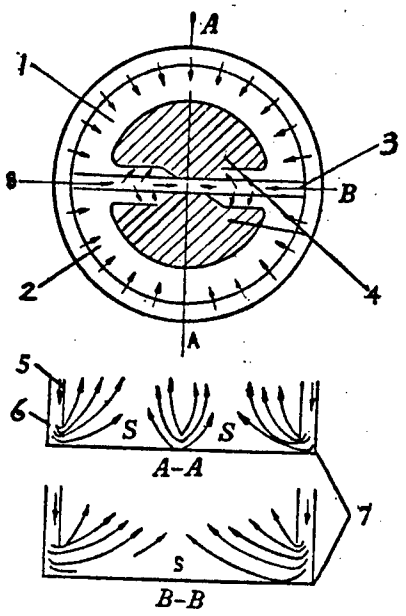

Figure 3. Stagnation Zone on the Upper Tubesheet Surface

1. Cold side
2. Hot side
3. Channel in the tube bundle
4. Stagnation zone
5. Jacket
6. Shell
7. Upper tubesheet surface
8. Stagnation point

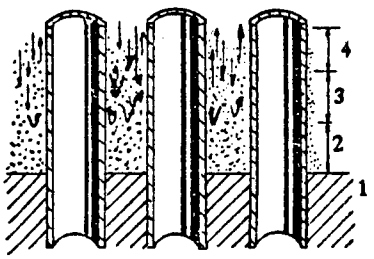

Figure 4. Mud Sediment Layer on Upper Tubesheet Surface

1. Upper tubesheet surface
2. Steam cushion zone
3. Alternately wet and dry zone
4. Wet Zone

wet zone, where the voids created by boiling are continuously filled by liquid. The middle is the alternately wet and dry zone, under which there is

the liquid-impermeable steam cushion zone. Concentration on impurities and wet and dry alternation of the heat transfer surface usually take place in this region. In the mud sediment, the gap between the tube and tubesheet can be considered filled by mud.

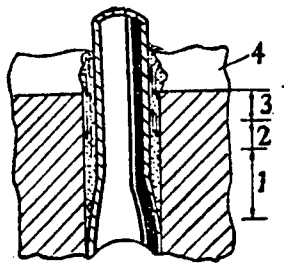

Figure 5. Mud Sediment in the Gap between Tube and Tubesheet

1. Steam cushion zone
2. Alternately wet and dry zone
3. Wet zone
4. Top of tubesheet

Tests on the thermohydraulic characteristics in the crevice between tubes and tubesheets were reported in Reference [3]. The tube material used experimentally was Invonel 600, and the gap was 0.3 mm. An electric heater was imbeded in the tube. The test specimen was inserted in a stainless steel autoclave for testing. The experimental results are as follows:

(1) It was proven that wet and dry alternation took place on the tube wall in the crevice;

(2) When the secondary-loop medium was treated by phosphate, phosphate precipitation was found on the tube wall in the crevice, but not on the tube wall outside the crevice;

(3) When the secondary-loop medium was treated by a volatile agent, although wet and dry alternation still occurred on the tube wall in the crevice, yet corrosion was not found.

3. Crevice between Tube and Support Plate

In the crevices between the tubes and support plate, the tubes are dented due to the compression by the corrosion product. This has attracted the attention to the support plate structure and the thermohydraulic characteristics of these crevices.

In the steam generators designed earlier, the support plate was a carbon steel structure with holes drilled in it. In operation, the volume of the support plate corrosion product is approximately twice that of the metal consumed, causing the simultaneous deformation of the tubes in the crevices,

as well as of the support plate itself. Based on a single phase flow calculation, only 3-8 percent of the total flow goes through the holes. Because the pressure drop of the secondary-loop medium across the crevices and holes is fixed, the flow resistance across the crevices will increase as the corrosion product is accumulating in the crevices. The effect of liquid insufficiency in the crevices will be aggrevated to accelerate the concentration and precipitation of impurities. Figure 6 shows the contact situation between the tube and the support plate, which indicates that the contact surface between the tube and the support plate is very small. The circumferential angle occupied by the contact surface is also limited. Near the contact surface, there is not enough liquid because the flow of the medium is obstructed, leading to a deterioration of the heat transfer and causing the wet and dry alternation on the heat transfer surface or formation of a steam cushion in the crevice. On the heat transfer surface with a larger gap, however, a normal boiling effect is created.

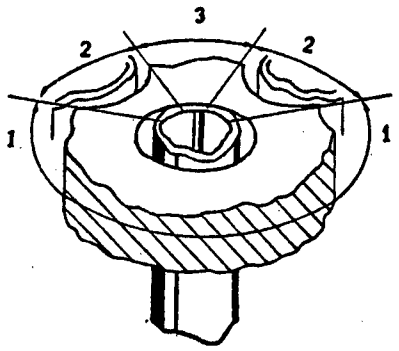

Figure 6. Contact between Tube and Support Plate

1. Boiling zone
2. Steam cushion zone
3. Metal-to-metal contact zone

Experimental studies of the thermohydraulic characteristics in the crevice between the tube and support plate have been conducted abroad [15,16], and results have shown that the wall temperature in the crevice was significantly higher than that outside the crevice. The boiling of circulating water in the crevice will lead to the concentration of impurities, dissolution of the tube and support plate material and removal of volatile additives (such as ammonia) to cause a pH change. The solution concentration is 5-20 times higher in the crevice than that in the circulating water. When there is impurity precipitation, the concentrating factor is even higher, related to the extent to which the solution is superheated.

4. Vibration-proof Rack at Tube Bundle Bend

When the steam-water mixture reaches the bend of the U-shaped tube, the gravimetric steam content and flow rate of the steam-water mixture attain

their maximum values. In Reference [5], based on a three-dimensional mathematical model, it was calculated that the secondary-loop medium flow rate at the tube bundle inlet was 0.84 m/sec, the flow rate of the steam-water mixture at the outlet of the tube bundle was increased to 6.71 m/sec and the gravimetric steam content of the tube bundle outlet reached 40 percent on the hot side and 26 percent on the cold side. The steam-water mixture flows transversely in the minimum-bend region and obliquely in the circular portion outside the tube bundle. In the minimum-bend region, the flow resistance coefficient is larger than the circular portion, while the flow rate is lower.

At the tube bundle bend and the vibration-proof rack it is difficult for the bubbles produced on the tube wall to separate because the gravimetric steam content is relatively high and the flow of the steam-water mixture is easily obstructed. Superheating is intermittently created, i.e., a "dry" condition is locally generated on the tube wall. If the secondary-loop medium contains a phosphate salt, it will be concentrated in the tube wall. After a bubble separates from the wall surface, it is again wetted by the secondary-loop medium. The concentrated phosphate in the tube wall is dissolved. Thus, on the alternately wetted and dried tube wall, the thinning of the wall will occur due to this frequent contact with a concentrated phosphate solution during the repeated precipitation and dissolution of the phosphate salt.

A simulated experiment on the thermohydraulic characteristics at the tube bundle, vibration-proof rack of steam generators manufactured by Combusion Engineering Corporation in the United Stateds was reported in Reference [3]. Thermocouples were used to measure the inner and outer wall temperatures at the vibration-proof rack, and the results are as follows:

(1) The inner wall of the vibration-proof rack obviously was alternately wetted and dried. It was most apparent in the 45° downward position, which was in agreement with the actual position where thinning occurred.

(2) Increasing the circulation ratio when the heat load and steam mass flow rate are fixed, or decreasing the heat load when the steam mass flow rate and circulation ratio are fixed, will alleviate the extent of wet and dry alternation of the tube wall at the vibration-proof rack.

IV. Measures to Improve Thermohydraulic Characteristics

When designing a steam generator, the designers are more and more concerned about improving the thermohydraulic characteristics from its structure design. Some foreign companies have already used measures to improve the thermo-hydraulic characteristics as the guidelines in the design of steam generators. For example, the stagnation zone and crevice area should be eliminated to the extent possible, mud sediment area in contact with the heat transfer surface should be minimized and concentration of impurities, wet and dry alternation and steam cushioning in the stagnation zone should be alleviated. In particular, the gravimetric steam content in the tubesheet surface on the hot side of the tube bundle should be decreased as much as

possible, and drain pipes should be arranged in stagnation zones. The measures to improve the thermohydraulic characteristics from the viewpoint of structure design are described in the following:

1. Increasing or Maintaining the Circulation Ratio

As the steam generator continues to evaporate more steam, its circulation ratio should be maintained at 3-5. By increasing the circulation ratio, it is possible to increase the transverse flow speed of the secondary-loop medium on the upper tubesheet surface toward the center of the tube bundle to slow down sedimentation and to reduce the stagnation zone. At the same time, the gravimetric steam decreased to minimize impurity concentration and wet and dry alternation in the stagnation and crevice areas.

In order to reduce the two-phase flow resistance in the riser and to ensure a certain circulation ratio, steam generators used in large nuclear power plants usually adopt the following measures:

(1) Adoption of a square arrangement for the tube bundle;

(2) Modifyication of the support plate structure to reduce the resistance against the two-phase flow[15];

(3) Improvement of the separation characteristics of the steam-water separator to decrease its resistance[17]; and

(4) Elimination of the water circulation regulating device in the downcomer[14].

2. Improving Support Plate Design

The design of the support plate should secure the tube bundle in place and prevent any damage to the tubes due to a combination of vibration, earthquake and accident. It is required that venting of the heat transfer tube be avoided and resistance to two-phase flow across the support place be minimized.

In steam generators designed earlier, the support plate chosen was usually the carbon steel type with holes drilled through as shown in Figure 7(a). Westinghouse Corporation and the Frenco-American Atomic Construction Corporation in France used support plates with triple and quadruple fins, as shown in Figures 7(b) and (d). Combustion Engineering Corporation in the U.S.[19], the Power Station League[18] of West Germany and the Thermomechanical Engine Corporation of Italy[20] adopted the grid type of support plates, as shown in Figure 7(c).

The support plates are made of 12 Cr steel by Westinghouse and Combustion Engineering, 13 Cr steel by France, and 300 series stainless steel by the West German Electric Power League. However, the use of a corrosion-resistant support plate material might lead to vibrational fatigue and microshock erosion as the gap between the tube and support plate increases.

3. Installing Flow Distribution Damper and Drainage Device

In the design of steam generators, because of the increasing circulation ratio, the flow rate of the secondary-loop medium in the downcomer and the transverse flow rate at the upper tubesheet toward the center of the tube bundle are also increased. In order to utilize these high flow rates fully, a flow distribution damper is installed between the tubesheet and the first support plate. The flow distribution damper should be so designed that the secondary-loop medium is guided to reach a uniform axial mass flow rate on it. Furthermore, a suitable flow rate at the upper tubesheet surface should be maintained to facilitate the penetration to the center of the tube bundle. Thus, the stagnation zone in the middle of the tube bundle, where mud sedimentation occurs, is held to a minimum. The inlet of a drainpipe can then be arranged there.

It is necessary to determine the diameter of the opening in the flow distribution damper and its distance from the tubesheet through an experiment or calculation.

The operation of a steam generator allows the drainage of 0.5-1 percent of the feed-water to reduce the solids in the circulating water and to remove the sediment on the tubesheet surface. The inlet of the drainpipe should be placed in the stagnation zone. If the dirt removal location is not arranged rationally, sediment thickness on the tubesheet could reach several hundred millimeters.

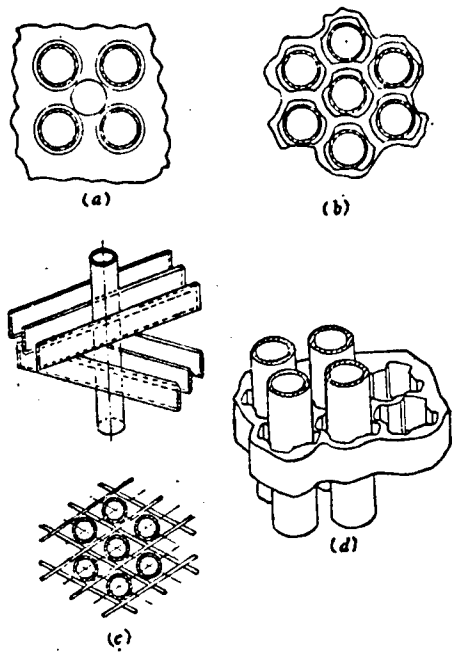

Figure 7. Some Support Plate Structures

(a) Drilled-hole type
(b) Triple-fin type with holes
(c) Grid type
(c) Quadruple-fin type with holes

4. Eliminating Crevice between Tube and Tubesheet

The connection between tubes and tubesheet in a modern steam generator usually does not employ a structure with any crevices. Reference [14] reported the explosive expansion of the tube at the tube plate (558 mm long) to allow the tube to expand uniformly and fill the 0.178-mm crevice. This is a new technology to eliminate the crevice between the tube and tubesheet.

Reference [21] reported a type of steam generator with a U-shaped tube double-drum structure. The tubes were connected using an inner-hole welding technique. A new TIG welding method was developed to be placed in the container. With the assistance of an automatic welder, welding was done inside the tubes. Inner tube welding could eliminate the crevice between tube and tubesheet and the tube expansion stress. Because each joint is thoroughly welded through, the connecting strength between the tube and tubesheet was improved.

5. Arranging Internal Pre-heater

As the steam pressure and evaporation increase, the arrangement of an internal pre-heater can save heat transfer surface. The internal-preheater should be placed in the semicircular portion on the cold side of the tube bundle. The feedwater is heated to approach the saturation temperature by the pre-heater. Because water from the outlet of the primarly loop is used to heat the feedwater, the logarithmic average temperature difference is raised.

The structure of an internal pre-heater can be divided into two types, i.e., transverse flow and axial flow of the secondary working medium on the shell-side. A transversely flowing pre-heater uses a dividing plate to create a reverse transverse flow or a branched upper and lower transverse flow. Its heat transfer is more effective than axial flow. However, the effectiveness of transverse-flow heat transfer is lowered because of the leakage of the secondary-loop medium as it flows transversely across the dividing plate.

Because of the problems in the arrangement of the transversely flowing preheater, it was decided to use an axially flowing structure in the steam generators designed by Combusion Engineering in the eighties[19]. The feedwater flows evenly downward in the gap between the shell and the jacket. Between the tubesheet and the flow distribution damper, it radially flows across the tubesheet. The design of the flow distribution damper in the pre-heater was based on the experimental results in flow distribution and transverse flow vibration which were verified in full-scale flow models.

V. Conclusions

Because corrosion damage to heat transfer tubes in the steam generators of pressurized-water nuclear power plants is closely related to the thermo-hydraulic characteristics, they have already drawn the attention of nuclear

power workers around the world. Presently, experimental studies of the thermohydraulic characteristics are urgently required so that the most up-to-date results can be applied to the design of steam generators in order to ensure the reliability and cost effectiveness of the nuclear power equipment. Some of the accomplishments in the study of thermohydraulic characteristics are relatively mature and can be applied to the design. Some of the problems still require further study, especially the thermohydraulic characteristics on the upper tubesheet surface, in the crevice the tube and support plate and at the vibration-proof rack near the tube bundle bend; the position and size of the aperture on the flow distribution damper; the determination of the two-phase friction resistance, local resistance in the riser and its cross-sectional steam content; and the varying patterns of the flow rate, pressure, wall temperature, gravimetric steam content and heat load of the secondary-loop medium on the shell-side. In order to study the problems mentioned above, it is necessary to develop model experiments with modern measuring techniques (such as high-speed photography, laser-speed sensing and radioactive isotope) and computations using multidimenstional mathematical models.

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CSO: 4008/13

BRIEFS

INFRARED SIMULTANEOUS INTERPRETATION DEVICE--An infrared simultaneous interpretation machine, capable of simultaneously translating nine different languages, and developed by the Guangzhou Electronics Technology Institute, passed technical appraisal in Guangzhou on 22 December. Specialists from over 20 units nationwide felt that this achievement reached the levels abroad for similar products and was a first for China. In the past, we have relied on imports of this type of equipment. After it has gone into production, it will save great quantities of foreign exchange, but also can be extended to use in conference and travel activity and in other intraoffice communications. In September, 1983, this equipment was used on a trial basis at an international conference held in the Great Hall of the People in Beijing and proved its excellent capabilities and was uniformly well received by Chinese and foreign specialists at the meeting. [Text] [Guangzhou NANFANG RIBAO in Chinese 26 Dec 83 p 4] 8226

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NEW PREPARATIONS OF CONTRACEPTIVE AGENTS REPORTED

Beijing YAOXUE TONGBAO [CHINESE PHARMACEUTICAL BULLETIN] in Chinese
No 12, Dec 1983 pp 53-55

[Article by Liu Qiming (0491 0366 2494)]: "Advances in the Research in New Preparations of Contraceptive Agents"]

[Text] Abstract: This essay describes advances in the research in some new preparations of contraceptive agents such as film preparation, long-lasting minute crystalline mixed-suspension preparation, new slow-release long-lasting contraceptive systems and medicated intrauterine contraceptive devices. Improvements in the preparations will not only increase the effectiveness of contraceptive agents and facilitate their use but will also reduce side effects and enhance their safety.

Birth planning is an important problem receiving widespread attention in the contemporary world. Ever since the 1950's when steroid hormone oral contraceptives were first discovered, many pharmaceutical chemists have carried out the reorganization of molecular structures and studied the relationship between structure and effect and successively discovered many effective contraceptive agents, thus contributing to the birth planning of mankind. [1] Since the 1970's, with the rapid advances in studies in the metabolic dynamics of drugs, in biopharmaceutics and in such subjects as the physiology of human reproduction and biochemistry, people have discovered that the manufacturing of drugs into various preparations will process the drugs into forms which are easy to take. More important is the research into the use of new and appropriate preparations so that they are suited to the physiological and pathological characteristics and the use of effective means to bring into full play the role of the drugs and reduce side effects. In recent years, because of improvements in preparations, many agents regulating birth have had their contraceptive effectiveness increased and side effects reduced, while their safety is guaranteed. The following is a brief summary of advances in the research in new preparations of agents regulating birth.

I. Contraceptive Film Preparations

The commonly used contraceptive agents in film preparation include the following:

A. Short-term oral contraceptive film: The norethindrone compound (short-term oral contraceptive tablets number I) and methyl progesterone compound tablets (oral contraceptive tablets number II) which are widely used at present have all been made into film preparation, with 1 small square to be taken every day and 24 squares (1 package) to be taken consecutively every month. Using the film preparation form makes it possible for the machines to stir the paste evenly for spreading on the film, thereby improving the protection of the workers. Also, the ingredients are well distributed so that the quality can be guaranteed and it is easier to take and carry.

B. External-use contraceptive film: It is a quick-acting preparation used in the vagina to kill sperm. It combines the new non-ion surface active preparation of menthyl benzol alcohol ether (TS 88) or nonyl alcohol ether (N P 10) with such film-forming material as polyethylene alcohol (PVA) to manufacture a film preparation that will quickly dissolve. Such a preparation possesses a strong capability of killing sperm without side effects and will not affect the natural environment of the vagina. Place one at the neck of the vagina before coitus and it can kill all the sperm discharged in one ejaculation.

C. Methyl ether contraceptive film [2]: It is a new progesterone compound to be used as a post-coital and spousal visitation contraceptive agent. Every tablet contains 0.5 mg of methyl progesterone and 0.8 mg of acetylethinether. At first, it was made in the form of an oil capsule [3] (called methyl ether contraceptive pill), but acetylethinether, which is one of the main ingredients, is relatively unstable in an oil solution and ethers can dissolve easily so that the storage period is short. After being made into a film preparation, it is in solid form, the agent is more stable and the quality can be better guaranteed. It is to be sucked under the tongue and can be absorbed fast. It can take effect quickly and is easy to take.

II. New Long-Lasting Contraceptive Injections

Long-lasting contraceptive injection is at present a widely used long-lasting contraceptive preparation. In the past, long-lasting contraceptive injections were made from converting short-term oral contraceptive agents into long-lasting contraceptive injections. The method is to take the steroid contraceptive agent which, using long-chain fatty acids, esterifies it into esters and then makes it into an oil preparation for injection. For example, each caproic acid progesterone compound injection preparation (long-lasting contraceptive injection number I delalutin) [4] contains 250 mg of caproic acid progesterone and 5 mg of valeric acid estrone, while each noristerate compound injection

preparation [5] contains 60 mg of noristerate and 5 mg of valeric acid estrone. The common drawback of this type of long-lasting contraceptive injection is that it requires a chemical process of esterification: the technology is complex, the quantity of medicated preparation large and the cost high. It is not satisfactory. In recent years, there has been successful research in manufacturing methyl progesterone or jia-yun-tong [3946 13147904] (progesterone?) directly into minute crystalline mixed-suspension fluid-injection preparation. For example, each methyl progesterone compound-injection contraceptive preparation contains 25 mg of methyl progesterone and 3.5 mg of estrone; thus the amount of preparation has been reduced greatly while the contraceptive effectiveness has been raised to a rate of more than 99.60 percent, and side effects have also been reduced. This new preparation, when compared with the oil injection preparation, has proved to have good results in rabbit tests [6]. If we use a preparation with a 50 percent rate of curbing ovulation [ED_{50}] as the criterion to compare the effectiveness of the agents, then the long-lasting anti-ovulation function ED_{50} of methyl progesterone mixed-suspension fluid is 0.94 mg/kg; and when compared with caproic acid progesterone and caproic acid methyl progesterone oil injection under the same conditions, it is 25.8 times and 7.6 times stronger than the last 2 items, respectively. Methyl progesterone mixed-suspension fluid is injected once into the leg muscle of the rabbit, and the amount of partial drug residue is 81.5 percent after the first weekend, 52.9 percent after the second weekend and 31.2 percent after the third weekend. By the fourth weekend, there is still a 15.8 percent drug residue. But after a similar injection of methyl progesterone oil solution, the amount of partial residue is 22.8 percent after 24 hours, 13.06 percent after 48 hours and only 5.3 percent after 72 hours. It can be seen that the methyl progesterone minute crystalline mixed-suspension fluid, manufactured after the improvement of the preparation, when used as an injection into the muscle, can store part of the agent for slow absorption, thereby allowing the short-term oral contraceptive agents to achieve the objective of becoming long-lasting. When compared with the aforementioned ester-type oil injection, it has also shown to be stronger and longer-lasting. This new long-lasting contraceptive injection is now widely popularized and used [7].

Mini-capsule of mixed-suspension fluid injection preparation: Recent research reports indicate that making methyl progesterone (15 mg) and valeric acid estrone (5 mg) into mini-capsules by using gelatin and gum acacia and then turning them into mixed-suspension fluid can also produce satisfactory results. Empirical observations of the metabolism of the agent show that 15 days after being injected into the muscle, the release of the agent is steady; then the agent gradually dissolves, and the speed of release declines intil the 27th day when it is all released. The contraceptive effectiveness is 98.72 percent. The amount of preparation is relatively small and there are few side effects.

High molecular biological dissolvable and slow-release injection preparation is another new injection preparation developed in recent years. The contraceptive agent is evenly stirred into biological dissolvable polymers and made into injection preparations. The speed of release after injection is solely determined by the body enzymes' role in dissolving polymers. Someone [9] has used poly L-lactic acid with 20 percent of norethindrone to make into a mini-capsule muscle injection fluid (one injection every 3 months) and it is now being clinically tested.

III. New Slow-release Long-lasting Contraceptive Devices--Mecicated Silicone Rubber Vaginal Ring

The use of silicone rubber to manufacture a slow-release progesterone vaginal ring is a new long-lasting contraceptive device under study and development in recent years. Silicone rubber, besides possessing the good elasticity of ordinary rubber, also has the characteristics of relatively good biological tolerance and consistency of drug release. When the progesterone-type contraceptive agent, carried in a container made of silicone rubber and made into the shape of a ring, is placed in the curved cavity behind the vagina, the agent can be continually and slowly released through the wall of the tube with a relatively consistent speed and small doses. Long-term contraceptive results can be achieved when they are absorbed by the mucous membrane of the vagina.

Folkman and others [10] have reported that agents contained in polymethyl silicone rubber tubes can, through the net structure of the polymer, be slowly released to the surrounding body fluids. Dzuik and others have reported [11] that when a silicone rubber capsule which has been immersed in steroid agents is implanted into the body of a sheep, the agent can be slowly released through the tube's wall and that this continued for a period of time. These important discoveries open for people a new path for slow-release long-lasting prepearations and such new long-lasting preparations as silicone rubber capsule, vaginal ring and intrauterine ring have subsequently appeared. Mishell and others have reported [12] that jiayuntong, mixed with the material of polymethyl silicone rubber, can be made into solid rings, with each ring containing 200 mg of jiayuntong. The ring is placed in the curved cavity behind the vagina on the 5th day after menstruation and removed after 3 weeks to be placed back again in the same manner in the following month after the period ends. The contraceptive result of the method is good but the amount of agent released by the ring is large (about 1 mg every day) and will cause irregular periods and serious bleeding. Also, because of the ring's relatively large size, it can easily pressure the mucous membrane of the vagina, causing hyperemia and infection of the membrane. It is no longer in use. Burton and others have reported [13] that be using the "wick-style" silicone rubber ring made with levo 18-methyl norethindrone, they can use the zero sequence and with a very low level (about 20 μg every day) consistently and slowly release the agent. The shape of the ring is also reduced (50-58 cm). Each ring can be used

continuously for 90 days and relatively satisfactory results have been obtained.

The "methyl silicone ring" [14] which our country has successfully manufactured and popularized in recent years is a silicone rubber agent contraceptive ring made with methyl progesterone. Each ring contains 200 mg of methyl progesterone, and when it is used, it is placed in the curved cavity behind the vagina. The agent can be slowly and steadily released through the silicone rubber tube wall--about 100 μg a day--and after having been absorbed by the mucous membrane of the vagina, has a long-lasting effectiveness of more than a year. Clinical tests have proved that the contraceptive result of this ring is good and is about 98 percent effective, with little side effects. The rate of perforation bleeding is about 7 percent and that of dislocation of the ring is 2.15 percent. The result of an evaluation [15] of internal secretions indicates that there is little impact on internal hormones, and in most cases, ovulation is not curbed. Thus there is little interference of the lower pituitary-ovary and it is relatively safe and reliable and easy to use.

IV. New Medicated Intrauterine Contraceptive Devices

Metal intrauterine contraceptive devices have been popular for many years. The advantages are that they can be used for a long time and are inexpensive. But there is a definite rate of ring dislocation and the contraceptive effectiveness is not satisfactory. Moreover, some women suffer from a high rate of perforation bleeding and serious increases in the amount of menstruation. In recent years, although research has improved the shape of the ring or added copper wires, it is still not satisfactory enough. But some better results have been obtained in the research of intrauterine contraceptive devices with progestin. According to the report of Alza Company in the U.S. [16], it has successfully researched and manufactured a kind of intrauterine contraceptive device containing progesterone which has a T-shaped tube made from the mixing of synthetic high-molecular polyethylene (PV) and polyacetic acid ethylene ester (PVA), each of which has 50 mg of progesterone. Every day about 65 μg is released and it can be used continuously for a year. It is claimed that beginning from 1969, when it was first tested, the result has been satisfactory and has a 98-percent effective contraceptive rate while the amount of blood lost during menstruation has markedly been reduced. It has now been commercially manufactured for sale. This kind of intrauterine contraceptive device with progesterone is also being studied and tested in our country.

SEI-mahgoub reported [17] that recently it conducted successful research in a type of new medicated intrauterine device. The contraceptive agent 18-methyl norethindrone and silicone rubber are mixed in the ratio of 2:1 and made into a wick with a diameter of 0.9 mm and a length of 20 mm. It is encased in a silicone rubber tube with an outer wall 0.41 mm thick

and an outer diameter of 2.5 mm formed into the shape of a ring. Each ring contains 10 mg of d-18-methyl norethindrone, of which 8 to 10 μg are released every day, and it is used continually for a year. After 200 clinical tests and 1,160 cycles, there has not been a single case of failure.

Based on the improvement of metal rings, intrauterine contraceptive devices with progestin have been developed and they can overcome the drawback of loss of excess blood during menstruation while the result has also been improved. But at present, each of these rings can only be used for a year and it is still not long enough. Now, continued research is being done to improve them and prolong their period of use from 3 to 5 years.

V. Other Contraceptive Agent Preparations

A. Long-lasting hypodermic implant preparations: When contraceptive agents are made into a type of preparation which is implanted hypodermically, the agent can be released slowly to achieve long-term contraceptive results. In the past, such implant preparations used high molecular material to make into a tube, with the agent being released steadily through the tube wall. But after this kind of preparation has been implanted for a definite period of time, the tube-shaped material has to be removed from under the skin, and it is not very convenient. Reports in recent years [18] indicate that contraceptive agents such as natural estrogen (estrone) have been made into tablet form and hypodermically implanted. It has been tested in 1,546 cases and 18,480 cycles, with a corrected failure rate of 0.273 percent. Continued observations for 1 to 8 years show that there has been relatively little interference with the women's menstruation and metabolism. Research is still going on in other countries.

B. Non-surgical sterilization preparations: To achieve the objective of sterilization, the common methods are tubal ligation and vasectomy, both of which achieve the result of sterilization by obstructing the movement of eggs or sperm. In recent years, our country has conducted successful research in a kind of phenol compound paste preparation [19] which can be injected into the oviduct so that the duct walls will be pasted together, thus achieving the result of permanent contraception. This agent preparation can avoid the pain of surgical sterilization and is made from phenol, hydrochloric acid atabrine and cholic acid. The method is to insert a special plastic tube through the vagina and the uterus cavity into the oviduct's opening and then to inject 0.12 ml of paste preparation respectively into the oviducts on both sides so that the agent will slightly corrode the tube cavity which will be blocked after healing, thereby achieving sterilization. Since 1972, there have been more than 2,000 clinical tests and analysis had been made of 1,708 cases in which the oviducts have been filled with more than 1 cm of the agent. The success rate is 99.30 percent. Recently,

research has been made to improve the prescription, to reduce the amount of preparation and to reduce side effects further. This has obtained good results and has become a non-surgical sterilization measure. The sterilization method of injecting the agent into men's seminal ducts is also being studied [20].

C. Prostaglandin vaginal suppository and sponge preparations: Recent [21] research has successfully used prostaglandin-type agents to make into long-lasting vaginal suppository or sponge preparations for use in preventing early pregnancies or in hastening parturition and induced parturition. Studies have reported that the prostaglandin F_{2a} compound long-lasting suppository is made from combining prostaglandin F_{2a} and hasten parturition material, using gelatin and getyl palrritate as the base and adding the appropriate amount of glycerine and EDTA-Zn salt to make into suppository form. It can be used for mid-term induced parturition or for hastening parturition. Most recent studies have reported [22] the use of 15 (s) 15-methyl prostaglandin F_{2a} methyl to make into a long-lasting vaginal suppository of 3 mg. It has been tested in preventing early pregnancies, and its effective rate reaches 73 percent. There are also reports from Japan of using such prostaglandin-type material with improved structure as Ono.802 to make a vaginal suppository, and it can also obtain relatively good results in preventing early pregnancies. In our country, research is being carried out in using 15 (RS) 15-methyl prostaglandin F_{2a} methyl to make sponge preparations and vaginal suppositories and long-lasting injection preparations for clinical tests of their appropriateness in preventing early pregnancies. The effective rate is more than 93 percent and good results are obtained.

Summing up, we can increase the effectiveness and safety of birth-planning agents through research in improving teh preparations according to the functional characteristics of the agents and the functional mechanics of human reproductive physiology. At the same time, the improvement of the preparations of agents will surely further advance the development of research in contraceptive agents.

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CSO: 4008/118

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TITLE: "A Discussion on Some Problems About the Mining Method in the Second Phase of the Project of Baoshan Copper Mine"

SOURCE: Changsha ZHONGNAN KUANGYE XUEYUAN XUEBAO [JOURNAL OF CENTRAL-SOUTH INSTITUTE OF MINING AND METALLURGY] in Chinese No 4, Dec 83 pp 86-87

TEXT OF ENGLISH ABSTRACT: In this paper, we shall discuss the research report on the feasibility mining engineering of Baoshan Copper Mine in the second phase of the project covering the mining method, underground mining method and mine production capacity suggested by the Lanzhou Designing Institute of Non-ferrous Metallurgy, and shall make an all-round demonstration and analysis. The different conclusions are suggested as follows.

The conclusion that the sublevel caving method can be used as the major basis in determining the mining method, that is, determining the underground mining method in the second phase of the project, is open to question. For the purpose of being suited to the characteristic that the ore body changes greatly, it is better to selectively use sublevel caving (with floor pillar) and open stoping with drawing chute located in foot wall etc. with various internal relations. And it is better to limit the mining capacity to below 1,000 ton/day.

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TITLE: "An Inquiry Into the Status and Development of Alluvial Gold Mining in Hunan"

SOURCE: Changsha ZHONGNAN KUANGYE XUEYUAN XUEBAO [JOURNAL OF CENTRAL-SOUTH INSTITUTE OF MINING AND METALLURGY] in Chinese No 4, Dec 83 p 78

TEXT OF ENGLISH ABSTRACT: This paper has analyzed the Hunan alluvial gold deposit and its present mining status. According to the mining experience at home and abroad, practical suggestions for the development orientation of Hunan alluvial gold mining in the future are put forward as follows: The riverbed and alluvium alluvial gold should be preferentially mined with bucket-chain dredges controlled by rope-spud method. As for valley saprolite alluvial gold deposit exploitation, tractor scrapers and bulldozers should be used for stripping; and tractor scrapers, front-end loaders and small power shovels, fitted with a portable mill for primary dressing, can also be utilized in placer extraction. The location programming for placer mining has been discussed. The formulas of break-even cut-off ore grade and maximum stripping ratio are presented.

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TITLE: "A Stimulating Study in Application of Kalman Filter to Airborne Radar Tracking System"

SOURCE: Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese No 6, 1983 pp 47-55

TEXT OF ENGLISH ABSTRACT: An application of the Kalman filtering theory and simulation results with computer are developed in tracking system of airborne firecontrol radar. The dynamic mathematical model of target, the linear filtering and simulation, approximation by the linear filtering, sensitivity simulation, maneuvering target tracking and adaptive filtering, etc., are shown. Simulating results show that this system is better than general system on the performance and the adaptive capability of maneuvering targets.

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TITLE: "A Modified Kalman Filter for Tracking Maneuvering Targets"

SOURCE: Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese No 6, 1983 pp 56-63

TEXT OF ENGLISH ABSTRACT: A modified Kalman filter, based on the model of filter bank for tracking maneuvering targets is presented in this paper. It detects the target manuever by judging whether observation residue exhibits bias. The maneuver acceleration command is estimated by damp least squares method only when the maneuver is detected, and then the filter will correct the state-prediction and its error covariance with the estimate. Otherwise the filter works as a single Kalman filter with zero maneuver acceleration command. Thus, a better compromise between the steady filtering accuracy and rapid response to maneuver is obtained. The computer simulation results show that the filtering accuracy is somewhat better than that of Moose's complicated filter bank and the computation burden is only 1/3.6 of Moose's filter.

CSO: 4009/44

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TITLE: "A Study on Chromosome Aberrations of Human Blood Induced in Vitro by n + γ Mixed Irradiation From the Heavy Water Reactor"

SOURCE: Taiyuan FUSHE FANGHU [RADIATION PROTECTION] in Chinese No 5, Sep 83 pp 353-354

TEXT OF ENGLISH ABSTRACT: Human peripheic blood were exposed in vitro 1.3m out of the horizontal hole of heavy water reactor at 2000 Kw power. The neutron spectrum was measured by solid state fission track neutron detector and γ ray dose by ^{7}LiF TLD. The kerma of blood sample was computed on the basis of the spectrum. The neutron dose was about 40 percent of the total mixed dose. The mean energy of neutronspectrum was 0.38 MeV and its effective energy 1.91 MeV. The neutron dose-range was about 6-170 rads and γ ray dose-range about 8-300 rads.

Blood samples were cultured for 48-52 hours after irradiation。 Dicentric, centric ring and acentric aberrations were counted. For n + γ mixed irradiation, dicentric plus centric ring gave the best fit to the second degree polynomial model with a = 0 (the regression line passed through the origin)

$$Y_{d_ic+\gamma} = (11.76 \pm 3.46) \times 10^{-4} D_{n+\gamma} (3.69 \pm 0.91) \times 10^{-6} D^2_{n+\gamma}$$

and acentric aberrations fited in with line model

$$Y_a = (22.64 \pm 1.55) \times 10^{-4} D_{n+\gamma}$$

The dicentric plus centric ring induced by neutron constituent in n + γ mixed irradiation fited to line model

$$Y_{d_ic+\gamma} = (-0.05 \pm 0.04) + (54.4 \pm 5.6) \times 10^{-4} D_n$$

The RBE values of dicentric plus centric ring induced by n + γ mixed irradiation for 180kVX ray fall with increase of dose in the range of experimental dose. They ranged from 2.11 to 1。16. Thus attention should be paid to neutron protection in reactor radiation protection.

CSO: 4009/34

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